generated is closed either with an ordinary cork or with an india-rubber stopper, and, with the object of arresting seleniuretted and sulphuretted hydrogen, the gas, as it passes from the flask to the mirror-tube, is brought in contact with lead acetate solution, sometimes bubbled through the liquid and sometimes passed through cotton-wool or over a roll of filter-paper saturated with the solution. Where cork has been in contact with arseniuretted hydrogen there is danger of sufficient of the arsenic compound being retained by this porous substance to render its continued use a possible source of error; with rubber there is always the chance that arsenic or antimony may be present as one of the constituents of the material, and as regards the use of lead acetate it has been urged that to bubble the gas through a small quantity of the solution is safer than to pass it through or over cotton-wool or filter-paper. The apparatus sent us has been designed to avoid the use of a cork or rubber stopper, and to include a convenient means of passing the gas through a minimum quantity of lead acetate solution. To a wide-necked flask of 200 c.c. capacity is fitted a hollow glass stopper, perforated by the gas-exit tube, which supports a bulb containing a small quantity of 10 per cent. acetate of lead solution. The stopper is ground to fit tightly into the neck of the flask, and as the gas passes up the exit-tube it bubbles through the lead acetate solution in the bulb and so on to a calcium chloride drying-tube, to which is attached the mirror-tube in which the arseniuretted hydrogen is decomposed. The apparatus is neat and effective.

THE additions to the Zoological Society's Gardens during the past week include three Derbian Wallabys (*Macropus derbianus*, ♂ ♀ and juv.) from Australia, presented by Captain Ben Jones; a Ring-tailed Coati (*Nasua rufa*) from South America, presented by Mr. Thomas Mackenzie; an Egyptian Jerboa (*Dipus aegyptius*) from North Africa, presented by Mr. J. Manuel; an Active Amazon (*Chrysotis agilis*) from Jamaica, presented by Mrs. V. A. Taylor; a Darwin's Rhea (*Rhea darwini*) from Patagonia, presented by Mr. H. F. Fox; a Large-billed Weaver-Bird (*Ploceus megarhynchus*, ♂) from Naini Tal, deposited; a Baya Weaver-Bird (*Ploceus baya*, ♂), two Black-throated Weaver-Birds (*Ploceus atrigularis*), a Black-headed Finch (*Munia malacca*), a Chestnut-bellied Finch (*Munia rubro-nigra*), two Hybrid Finches (between *Munia malacca* and *M. rubro-nigra*) from India, presented by Mr. Frank Finn; two Bennett's Wallabys (*Macropus bennetti*) from Tasmania, a Black Wallaby (*Macropus ualabatus*) from New South Wales, a Ring-necked Parrakeet (*Palaeornis torquata*) from India, an August Amazon (*Chrysotis augusta*) from Dominica, fourteen Algerian Skinks (*Eumeces algeriensis*) from North-west Africa, a Derbian Sternothere (*Sternothaerus derbianus*) from West Africa, three Simony's Lizards (*Lacerta simonyi*) from the Canaries, eight Three-streaked Skinks (*Mabuia trivittata*), two Streaked Skinks (*Mabuia vittata*), a Hissing Sand Snake (*Psammophis sibilans*) from Syria, four Grey Monitors (*Varanus griseus*), five Common Skinks (*Scincus officinalis*), four Ocellated Sand Skinks (*Chalcides ocellatus*), six Turkish Geckos (*Hemidactylus mabouia*) from Western Asia, deposited; an Axis Deer (*Cervus axis*, ♂) from India, purchased; six Silver Pheasants (*Euplocamus nycthemerus*), four Gold Pheasants (*Thaumalea picta*), six Common Pheasants (*Phasianus colchicus*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN JULY.

July 1. 9h. Jupiter in conjunction with moon. Jupiter 3° 42′ S.
1. 19h. Saturn in conjunction with moon. Saturn 3° 36′ S.
2. 9h. 29m. to 9h. 47m. Moon occults B.A.C. 6710 (mag. 6·0).
3. 11h. 2m. to 14h. 6m. Transit of Jupiter's Sat. III.
5. 9h. Saturn in opposition to the sun.
15. Venus. Illuminated portion of disc = 0·936, of Mars = 0·900.
17. 10h. 34m. Minimum of Algol (β Persei).
22. 10h. 59m. Moon in conjunction with α Virginis (Spica).
24. Saturn. Outer minor axis of outer ring = 18″·08.
28. 9h. 51m. to 11h. 6m. Moon occults 21 Sagittarii (mag. 4·9).
28. 11h. Jupiter in conjunction with moon. Jupiter 3° 37′ S.
29. 0h. Saturn in conjunction with moon. Saturn 3° 34′ S.
29. 8h. 33m. to 9h. 48m. Moon occults *d* Sagittarii (mag. 4·9).

BLACK SPOT ON JUPITER.—On June 2, Sig. J. Comas Sola, working at the observatory of Barcelona with a six-inch Grubb equatorial (power 200), noticed a strange marking on System II. of the planet's belts. From the time at which it passed the central meridian on that day its longitude would appear to be about $\lambda = 73°\cdot1$; its latitude would be about 15°.

The tone of the spot is almost black, with a light garnet tinge, and might without close attention be mistaken for the shadow of a satellite. It is very sharp and circular, but on careful examination a very pale penumbra is seen before and behind the spot itself, the posterior penumbra being the more prominent of the two.

No signs of this spot were apparent on May 31.

TEN-YEAR GREENWICH STAR CATALOGUE FOR 1890.—The second ten-year star catalogue recently issued from the Royal Observatory forms Appendix II. to the *Greenwich Observations* for 1898, and contains the reduced places of 6892 stars for the epoch 1890·0, from observations made with the transit circle during the period 1887–1896.

The various corrections investigated are described at length, one interesting point brought out being that the observations from 1895–1899 show a diurnal change in the position of the nadir, the observations taken about noon and midnight giving positive corrections to the observations made near the time of sunset.

Comparisons are also given with the data of other standard catalogues, from some of which the proper motions of 174 stars are deduced.

NEW NEBULÆ.—In the *Comptes rendus* (vol. cxxxii. pp. 1465–1467) M. Bigourdan gives a descriptive table of twenty-one new nebulæ discovered with the north-west equatorial of the Paris Observatory, bringing up the number found in this way to 392.

PARALLAX OF μ CASSIOPEIÆ.—The eighteenth volume of "Contributions from the Observatory of Columbia University" contains an investigation of the parallax of μ Cassiopeia, made by Mr. G. N. Baur from the Rutherfurd photographic measures of twenty-eight plates of the region taken during 1870–1873.

The final value determined for the parallax is

$$\pi = 0''\cdot238 \pm 0\cdot014.$$

A table is also included showing the positions of fifty-six of the neighbouring stars used in the determination.

NEGATIVE AFTER-IMAGES AND COLOUR-VISION.

FOUR years ago I described an apparatus by which apparent transformations of colour could be produced (*Proc. Roy. Soc.*, vol. lxi. p. 268; NATURE, vol. lvi. p. 128). The essential part of it is a disc, partly black and partly white, having an open sector at the junction of the black and white portions, as shown in Fig. 1. If such a disc is caused to turn five or six times in a second while its surface is strongly illuminated, a coloured object placed behind it and viewed intermittently through the opening generally appears to assume an entirely different hue, more or less approximately complementary to the true colour of the object. A piece of red ribbon, for example, is seen as bluish-green and a green one as pink. The effect is due to the formation of negative after-images upon the white portion of the disc.

A number of observations made with this apparatus showed that the "pulsative after-images," as they may be called, differed in several important respects from the ordinary negative after-images seen upon a white ground after the gaze has been fixed for some time upon a coloured object. Among other things, they often appeared much more intense or saturated, which for obvious reasons was rather surprising. And again, it was found that the colours of the pulsative and of the ordinary after-images were sometimes very different. The pulsative after-images of red, of purple and of orange, for instance, were all of nearly the same bluish-green tint, and those of yellow and of blue were generally pink, showing considerable variations from the true complements. These and other anomalies led me to make some experiments with spectrum colours, which could be blended into uniform mixtures of known composition, instead of with pigments, the apparatus employed for the purpose being a simple form of Sir Wm. Abney's well-known "colour-patch" apparatus. The experiments, of which a short account is here given, are fully described in a paper recently communicated to the Royal Society (*Proc. Roy. Soc.*, May 23).

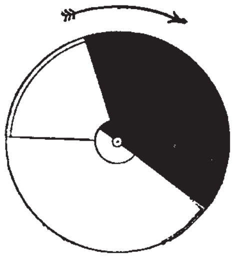

FIG. 1.

A short pure spectrum, some three or four inches long, is projected, by means of a spectroscope collimator, a prism and an achromatic lens, upon an arrangement known as a "slit-screen." This consists of a wooden board having an oblong window over which slide three brass slit-frames carrying adjustable slits. The two outer slit-frames are attached to sliding shutters, which serve to cover such portions of the window right and left of the slit-frames as would otherwise be open to the light; the spaces between the middle slit-frame and the two outer ones are closed by opaque black ribbons, constituting miniature spring-roller blinds. Each slit-frame can be moved independently to any desired position and clamped by a set-screw. When it is necessary to use larger portions of the spectrum than can be transmitted by the slits, the slit-frames and their appurtenances are removed from the screen and the spectrum is dealt with by means of one or more thin metal plates, which are inserted into a second pair of guides fixed on the other side of the screen. Each of these guides has three parallel saw-cut grooves in it, so that plates sliding in different pairs of grooves may be made to overlap one another, and thus screens or openings of almost any desired width may be provided with very little trouble. The selected portions of the spectrum pass through the slits to a large lens, which projects upon a white screen the image of a circular aperture in a diaphragm placed just in front of the prism. This image, which is 1½ or 2 cm. in diameter, constitutes the colour-patch; it is illuminated by a uniform mixture of the spectrum-rays transmitted by the slit-screen. When the wave-lengths of the light are to be determined a screen of ground glass is put in the place of the opaque white screen and the slit of a spectroscope is brought near the bright image on the glass. To produce a bright ground upon which to see the after-images a beam of white light, derived from the same electric arc as the spectrum, is directed upon the screen. The white light passes through the aperture of an iris-diaphragm, and a lens is placed to project an image of the aperture upon the screen. The "white-light disc" so formed is concentric with the colour-patch, and in most cases of slightly greater diameter.

In the path of the two beams of light illuminating the colour-patch and the white-light disc is placed a zinc disc having two apertures, one near the centre to admit the spectrum-rays, the other near the circumference to admit the white light. This is caused to turn about five times in a second, and the apertures are so arranged that the sequence of phenomena produced upon the screen may be as follows:—The colour-patch is projected for about 1/40 second, then it is extinguished and immediately succeeded by the white-light disc; this remains for 3/40 second, and is followed by an interval of darkness lasting 1/10 second, after which the colour-patch reappears and the cycle begins again. The appearance presented to the eye when the true colour of the patch is green is that of a purple disc surrounded by an annulus of flickering white. Other colours, of course, produce pulsative images of different hues. It is sometimes better to view the pulsative image directly by means of an eye-piece instead of receiving it upon a screen; two or three methods by which this can be effected are described in the paper.

Perhaps the most interesting of the various effects observed with this apparatus is one which appears to throw some light upon the origin of the pulsative image and to show why the true colour is so completely lost. It was noticed that when the white-light disc was made a little smaller than the colour-patch, the pulsative image, which was in this case of the same size as the white-light disc, was surrounded by a dark ring. This observation led me to make what is called in the paper the "black spot" experiment. A circular piece of tinfoil was gummed to a glass plate which was placed behind the iris-diaphragm, a sharply defined black spot being thus formed in the middle of the white-light disc, as indicated in Fig. 2, where the outer circle represents the white-light disc, the shaded circle the colour-patch, and the inner one the black spot upon the white-light disc. The diameter of the black spot was made, after several trials, 0·6 cm., or rather more than one-third of the diameter of the colour-patch. Suppose the colour-patch to be green. When the apparatus is worked, the patch becomes purple; the site of the black spot, being strongly illuminated five or six times in a second by green light, might be expected to appear green; but it remains perfectly black; no trace of a flicker of green light can be seen upon it. This induced blindness is most conspicuous when the light is green or yellow; it does not occur at all with extreme red or with violet light; nor does it generally occur if the luminosity of the colour-patch is reduced below a certain limit, that of the white-light disc remaining constant. A colour of feeble luminosity can be seen upon the black spot, while a brighter cannot, which is a paradox; and it was noticed that as soon as the spot became distinctly coloured, the pulsative image almost disappeared. Absence of colour from the black spot is essential for a good pulsative image.

It is clear that we have here an example of what I have called in other papers a border effect; in certain cases light has the power of exciting some action just outside the boundary of the image projected upon the retina. The black spot is, of course, merely a device for exhibiting in a convenient manner a border effect which extends for about half a degree beyond the white light impression. The experiment proves conclusively that, under the given conditions, white light has the power of restraining the visual sense-organs adjacent to those upon which the white light actually falls from responding to the green stimulus. This is of importance as indicating what occurs within the area illuminated by white light, for it would seem to follow *a fortiori* that the sense-organs which are directly acted upon by the white light must be similarly incapacitated from evoking any green sensation. In the formation of the pulsative image, then, it is not the fact, as generally believed, that the green sensation is produced for a moment and then swamped by a more powerful white one so completely as to escape notice; it actually never comes into existence at all. Nevertheless, the effects of fatigue by green are exhibited, and the physically white ground is seen as purple.

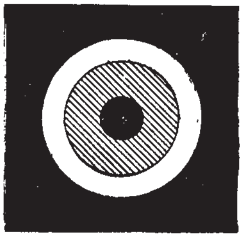

FIG. 2.

Only one possible explanation of the phenomenon has yet occurred to me. The facts can be accounted for in a perfectly simple manner if we suppose, as postulated by the theory of Hering, that there is an independent white sensation, and, further, that the latent period for a colour sensation is very much greater than that for white. For green, under the conditions of my experiments, the latent period would be at least 1/40 second, while for white it can hardly exceed 1/500 second, though the luminosity of the two may be as nearly as possible equal. The latent period for red is probably not very different from that for green under similar circumstances, while that for blue is considerably greater.

If in a darkened room a ray of green light is admitted to the eye for 1/40 second, one sees a flash of green; but, assuming that the suppositions which have been put forward are correct, the visible flash is not contemporaneous with the physical illumination. One does not begin to experience the green sensation until after the green ray which excited it has been shut off. What is actually perceived is, in fact, a positive after-image, the duration of which may be considerably longer than that of the stimulus. But if a sufficiently luminous white surface is presented to the eye immediately upon the expiration of the brief period of stimulation by green light, the after-image formed will not be positive, but negative, and the only colour perceived will be purple. The fatigue to which the negative image is due must have been set up during the latent period, when no image at all was actually perceived.

The formation of vivid pulsative images depends not only upon the latent period, but also upon persistence, luminosity, the duration of the primary impression and of the periods of light and darkness, and upon other circumstances. And the conditions which are best for some colours are not so for others. This fact obviously suggests that the pulsative image might afford a means of analysing compound colour-sensations, though so far it has been found available only to a limited extent. If the complete spectrum is projected upon the screen, it is seen at once that the blue-green pulsative image of the red, and the purple pulsative image of the green, are far more intense than the pulsative images of the yellow, the blue and the violet portions of the spectrum. Accordingly, if we make an orange colour-patch by combining red and yellow rays, it is not surprising to find that its pulsative image is blue-green, hardly differing at all from that of red, instead of sky-blue, which is the colour of the ordinary after-image of orange. Now the pulsative image of a patch illuminated by the simple orange rays of the spectrum is also found to be blue-green; hence the inference is clearly suggested that the spectral orange rays excite a red sensation. This particular fact will probably be regarded as one which needs no demonstration, but it is mentioned as an illustration of the proposed method of analysis. Several others in which the conclusions can be verified by trial might be given. Now it is noticed that under most ordinary conditions the purple pulsative image of green is more easily produced than that of any other colour. Under the same conditions we find that the pulsative images of yellow, of blue and of white are purple, and, assuming that the test referred to is a sound one, we conclude that yellow, blue and white all excite a green sensation. The proposed method of analysis may probably be carried much further than has yet been done.

This paper also contains an account of some new observations upon a class of phenomena to which I have drawn attention in a former communication (*Proc. Roy. Soc.*, vol. lx. p. 368; NATURE, vol. lv., p. 367). If the image of a white object is suddenly formed upon the retina after a period of darkness, the object generally appears to be surrounded for about one-tenth of a second by a narrow red border. It was noticed that when the bright object producing the image was looked at through variously coloured glasses the red border did not appear unless the glass used was capable of transmitting red light, and it was suggested that the phenomenon was due to sympathetic excitation of the "red nerve-fibres" lying immediately outside the portion of the retina directly affected by the radiation. The orange and yellow glasses employed for the observations referred to of course transmitted red light. Using the pulsative image apparatus with the eyepiece method, I now find that the simple red, orange and yellow rays of the spectrum, whether alone or in conjunction with any others, are competent to produce the red borders. The effect stops short at the beginning of the greenish-yellow. When blue and green rays are employed to illuminate the patch, either separately or in combination with each other, a blue-green border is produced. This is less intense than the red one before referred to, but if viewed in the manner described in the paper, the appearance of the green border due to pure spectral blue light of about λ4700 is very striking. Violet produces no coloured border of the kind, and its admixture with other rays has no sensible effect upon the phenomenon. It can hardly be doubted that effects which occur, sympathetically as is suggested, just outside the boundary of the physical image, must also occur within the boundary; and if that is so, it follows that red, orange and yellow rays, nearly up to the beginning of the greenish-yellow, excite a red sensation, while green and blue excite a green sensation. There is at present no evidence of the same kind as to the existence of any other fundamental colour-sensation, though there must, of course, be at least one more.

The bearing of these border experiments upon theories of colour-vision is indicated in the paper. The following is among the most important points referred to. It is found that a comparatively small proportion of red mixed with other spectral rays results in the formation of a red border. According to the Young-Helmholtz theory, green spectral rays excite the fundamental red sensation to about the same extent as orange-red rays; yet no red border is formed by the green, though that formed by the orange-red is very strong. The natural deduction is that no red sensation is excited by green light.

As regards a different point which has been much debated, certain observations seem to be absolutely conclusive. According to Helmholtz the phenomena of simultaneous contrast are due entirely to mental judgment; according to Hering their origin is a physiological one. Experiments with one of the eyepiece methods, in which the apparent diameter of the pulsative image is about one-fourth of that of the white-light disc or field of view, seem to place the matter beyond dispute. If a purple pulsative image is produced from a strongly illuminated green colour patch, the whole of the physically white field surrounding the patch appears to be purple. It cannot possibly be that the colour of the ground is a psychological effect resulting simply from contrast with green, for no green whatever is consciously perceived; the cause must necessarily be of a physiological nature. A similar effect is produced in an even more striking degree by blue and by violet colour-patches, the whole field appearing to be of the same hue as the pulsative images, namely orange and yellow. Phenomena of simultaneous contrast, as they are called, are therefore certainly not in all cases to be explained solely on psychological grounds.

The experiments which have been discussed establish nothing decisively in favour of either of the two principal theories of colour-vision. Some of the observations seem to support the Young-Helmholtz theory, others that of Hering; others, again, appear to indicate that neither theory in its present form is tenable. I venture to think that our knowledge of the subject might be materially increased by further experiments on the lines of those described.

SHELFORD BIDWELL.

THE SECOND INTERNATIONAL CONFERENCE FOR THE EXPLORATION OF THE SEA.

AFTER the International Conference which met at Stockholm in June 1899 for the consideration of a scheme for the systematic scientific study of fishery questions, it was proposed to meet again to complete the programmes at Christiania in the autumn of 1900. Various circumstances made it necessary to postpone the meeting, which eventually took place in the second week of May, when representatives of Germany, Belgium, Denmark, Finland, Great Britain, Norway, Holland, Russia and Sweden (the order is that adopted in the official *compte-rendu*—alphabetically in the French language), to the number of twenty-five, assembled in Christiania. The delegates included Dr. Herwig, president of the German Society for Promoting Sea-fisheries; Profs. Krümmel and Brandt of Kiel, and Profs. Heincke and Henking from Germany; Prof. Gilson of Louvain from Belgium; Captain Drechsel, Dr. Martin Knudsen and Dr. C. G. J. Petersen from Denmark; Dr. Nordqvist from Finland; Sir Colin Scott Moncrieff, Prof. D'Arcy Thompson, Dr. H. R. Mill and Mr. W. Garstang from Great Britain; Prof. Nansen and Dr. Hjort from Norway; Dr. P. P. C. Hoek from Holland; Dr. Knipovich from Russia; and Profs. Pettersson and Cleve, Dr. Trybom, Captain Maechel and Messrs. Wijkander and